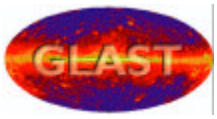	Document # **LAT-SS-02236-02**	Date Effective 28 October 2003
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Document Title **CAL FM Crystal Detector Element Qualification Plan**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter Flight Model

Crystal Detector Element Qualification Plan

DOCUMENT APPROVAL

Prepared by:

J. Eric Grove CAL Subsystem Instrument Scientist	Date

Nick Virmani CAL Subsystem Quality Assurance Manager	Date

Approved by:

W. Neil Johnson CAL Subsystem Manager	Date

CHANGE HISTORY LOG

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02	28 October 2003	Initial Release

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1 INTRODUCTION

1.1 PURPOSE

This document details the qualification test plan for Flight Model (FM) Calorimeter (CAL) Crystal Detector Elements (CDEs) assembled at Swales Aerospace. The qualification tests shall be performed at NRL.

1.2 SCOPE

We describe the qualification test program for FM CDEs. These qualification tests are designed to ensure that CDEs assembled at Swales will meet the relevant requirements identified in the CAL FM Crystal Detector Element Specification (LAT-SS-01133).

Components of the CDE – specifically the CsI(Tl) crystal and the photodiode assembly – shall have been qualified separately under separate programs.

1.3 APPLICABLE DOCUMENTS

The following documents are applicable to the extent specified within. Unless otherwise indicated, the latest issue in effect shall apply. In the event of a conflict between these documents and the contents of this document, those contained herein shall be considered the superseding requirement.

GE-00010	GLAST LAT Performance Specification
LAT-SS-00010	LAT Performance Specification – Level II (b) Specification
LAT-SS-00018	LAT CAL Subsystem Specification - Level III Specification
LAT-SS-00210	LAT CAL Subsystem Specification – Level IV Specification
LAT-SS-00601	LAT Calorimeter Structure to CDE Interface Control Document
LAT-TD-00381	LAT Calorimeter CDE Light Yield Calibration Procedure
LAT-PS-00809	LAT Calorimeter CsI Crystal Handling and Shipping Procedure
LAT-DS-00820	LAT Calorimeter CsI Crystal Performance Specification
LAT-DS-00209	LAT Calorimeter Flight Dual PIN Photodiode Specification
LAT-PS-01330	Calorimeter Flight Photodiode Assembly Soldering & Staking Process Specification
LAT-PS-01534	Calorimeter Flight Model Photodiode Assembly Specification
LAT-PS-01331	Calorimeter Flight Crystal to PDA Bonding Process Specification
LAT-PS-01332	Calorimeter Flight Crystal Wrapping and Capping Process Specification
LAT-SS-01133	Calorimeter Flight Crystal Detector Element Specification
LAT-DS-01900	Crystal Detector Element Assembly Drawing
LAT-MD-00228	Calorimeter, Tracker, and Data Acquisition Contamination Control Plan
LAT-PS-02571	CAL Crystal Detector Element Optical Test Procedure
LAT-PS-02572	Process Specification for the Bond Strength Testing of the CDE

1.4 DEFINITIONS AND ACRONYMS

1.4.1 Acronyms

CAL	Calorimeter Subsystem of the LAT
CDE	Crystal Detector Element
DPD	Dual PIN photoDiode
GLAST	Gamma-Ray Large Area Space Telescope
LAT	Large Area Telescope
PDA	PhotoDiode Assembly
TBD	To Be Determined
TBR	To Be Resolved

1.4.2 Definitions

Analysis	A quantitative evaluation of a complete system and/or subsystems by review/analysis of collected data
Demonstration	To prove or show, usually without measurements of instrumentation, that the project/product complies with requirements by observation of the results.
Inspection	To examine visually or use simple physical measurement techniques to verify conformance to specified requirements.
Simulation	To examine through model analysis or modeling techniques to verify conformance to specified requirements
Testing	A measurement to prove or show, usually with precision measurement or instrumentation, that the product complies with requirements.
Validation	Process used to assure the requirement set is complete and consistent, and that each requirement is achievable.
Verification	Process used to ensure that the selected solutions meet specified requirements and properly integrate with interfacing products
µm	micrometer
Mm	millimeter

2 INTRODUCTION

2.1 FM CDE COMPONENTS

The Flight CDE assembly consists of the following components. The CDE assembly drawing is LAT-DS-01900. Figure 1 shows a cartoon of the CDE assembly.

- One FM CsI(Tl) scintillating crystal, which is a rectangular parallelepiped with a chamfer on the corners of the long dimension, as defined in LAT-DS-00820.
- Two FM Photodiode Assemblies (PDAs), one bonded to each end of the CsI crystal. As defined in LAT-PS-01534, each PDA consists of:
    - One Dual PIN photoDiode (DPD) as defined in LAT-DS-00209, and
    - Two sets of interconnect wire pairs attached to the leads of the DPD.
- Two optical bonds attaching the PDA assemblies, one to each CsI crystal end using a DC93-500 silicone optical adhesive in accordance with LAT-PS-01331.
- One VM2000 Optical Reflective Wrap sealed with acrylic-adhesive Kapton tape applied in accordance with LAT-PS-01332.
- Two Machined End Caps attached over bonded PDAs and optical reflective wrap at both ends of the crystal to close out the ends of the CDE in accordance with LAT-PS-01332.
- One label indicating crystal serial number and orientation as defined in the FM CDE Specification (LAT-SS-01133).

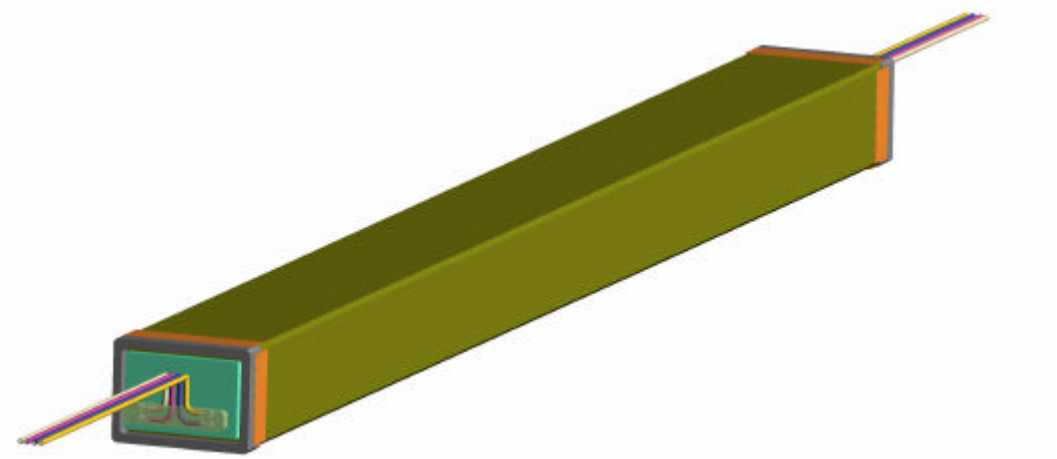

Figure 1: Crystal Detector Element assembly. Note that the CDE is depicted with its "top" surface – with the seam-sealing tape – down. The seal tape is therefore not shown. The CDE assembly drawing is LAT-DS-1900.

2.2 TRACEABILITY

The CsI(Tl) crystal and the photodiodes are individually serialized by the manufacturers in the manner indicated in their respective specification documents. Full traceability of these serial numbers shall be maintained throughout the entire process of CDE assembly.

The DC93-500 silicone encapsulant and DC92-023 primer are identified by batch numbers and subject to an expiration date. A single batch is a sufficient quantity to make many optical bonds. Batch number and expiration date shall be traceable for all flight CDEs.

The VM2000 wrapper is identified by the lot and roll number of its parent roll. One roll is sufficient to make hundreds of wrappers. No further identification of wrapper within its lot and roll need be given. Wrapper lot number and roll number shall be traceable for all flight CDEs.

The end caps are identified by lot number. One lot of end caps is sufficient for a few tens of CDEs. End cap lot number shall be traceable for all flight CDEs.

Each assembled CDE shall be serialized by its unique component crystal.

One “lot” of CDEs shall be comprised of the 12 CDEs assembled on a single bonding workstand segment. If fewer than 12 CDEs are bonded in a given session, only those CDEs that are bonded in a given session at a single workstand segment can be considered as a lot.

Full traceability of the serial numbers, batch numbers, and lot numbers specified above shall be maintained. The bonding and wrapping log shall document the serial, batch, and lot numbers of the components that comprise each assembled CDE.

3 CDE QUALIFICATION PROGRAM

Qualification tests shall be performed on CDEs manufactured to Flight specifications with the Flight process. The Qualification lot shall contain 12 CDEs.

The outline of the Qualification program is shown in Table 3-1. The twelve Qualification CDEs are number 01 to 12. The tests are listed in sequence, and the CDEs on which each test will be performed are indicated with an 'X'.

Step	Qualification test	Qualification CDE number											
		01	02	03	04	05	06	07	08	09	10	11	12
1	Visual inspection	X	X	X	X	X	X	X	X	X	X	X	X
2	Mechanical	X	X	X	X	X	X	X	X	X	X	X	X
3	Optical	X	X	X	X	X	X	X	X	X	X	X	X
4	Thermal cycle	X	X	X	X	X	X	X	X				
5	Rise to altitude										X		
6	Bond strength					X	X	X	X	X	X		

Table 3-1: Sequence of CDE qualification tests.

3.1 VISUAL INSPECTION

Each CDE shall be subject to in-process and final visual inspection, as listed here and within the PDA bonding process specification (LAT-PS-01331) and the wrapping and capping process specification (LAT-PS-01332).

CDEs failing the visual inspection shall not be accepted into the Qualification lot.

3.1.1 Requirements

As specified in the PDA bonding procedure (LAT-PS-01331), each PDA optical bond shall be inspected for evidence of delamination, voids, or other significant flaws on the bond edge. This inspection shall be performed as the bond is released from its mold, between 23 hours and 74 hours after it is injected, depending on the stage in the CDE assembly cycle. This inspection may be performed with no magnification or handheld magnification up to x10. Failure to cure, obvious delaminations, presence of 4 or more visible voids, or voids larger than 2 mm shall be grounds for rejection.

As specified in the CDE wrapping and capping procedure (LAT-PS-01332), prior to wrapping, each CDE shall be inspected for significant damage to the crystal volume, chamfers, and bonding faces. This inspection shall be performed with no magnification. Cracks anywhere in the crystal longer than 5 mm and chipped or shattered areas on the bonding face larger than 5 mm shall be grounds for rejection. Cracking, shipping, or shattering damage to the chamfer that extends over more than 20 mm shall be grounds for rejection.

As specified in the CDE wrapping and capping procedure (LAT-PS-01332), after wrapping and capping, each CDE shall be inspected for proper VM2000 wrapper alignment and tightness, wrapper seam sealing tape length, machined end cap tape placement, and end cap seating. These requirements are summarized here.

- The wrapper shall lap over itself on the top face of the crystal, and the overlapped portion of the wrapper shall not be skewed out of alignment by more than 0.7 mm at either end.

- So that the wrapper does not interfere with the placement of the machined end cap, neither end of the wrapper shall extend past the end of the crystal.
- The wrapper seam on the top face of the crystal shall be covered with a 312 mm (+0 mm, -1 mm) strip of 12.7 mm wide Kapton tape. The tape length is chosen so that it does not extend beneath the flange of either end cap, but its ends are covered by end-cap mounting tape.
- The wrapper shall be tight after both ends caps are taped in place.
- The end-cap mounting tape shall not extend onto the chamfers of the end cap. This tape shall cover only the lip of the end cap.
- Both end caps shall be firmly seated onto the crystal end faces such that they do not move when modest finger pressure is applied axially to a corner of the end cap.

Prior to shipping to NRL, each completed CDE lot shall be inspected for quantity and condition.

3.2 MECHANICAL

The Qual CDEs shall have overall dimensions (including bonded PDAs and Optical Reflective Wrap) not to exceed those given in Table 3-2. A specific subset of those dimensions of each CDE shall be inspected to meet LAT-DS-01900. Each CDE shall be weighed with precision and accuracy not to exceed 1 gram.

3.2.1 Requirements

Dimensional and weight requirements are given in the CAL Flight Model Crystal Detector Element Specification, LAT-SS-01133.

3.2.1.1 PDA Location

As specified in the CAL Flight Model Crystal Detector Element Specification, LAT-SS-01133, the PDAs shall be positioned on the CsI crystal end faces such that they will not contact the end cap. This results in positioning of the PDAs on the crystal end faces with the dimensions and tolerances given in LAT-SS-01133. The PDA location shall be referenced from the Top and either the front or rear crystal surfaces defined in the CsI Crystal Performance Specification, LAT-DS-00820. The positioning dimensions and tolerances are shown in the Calorimeter CDE Assembly Drawing, LAT-DS-1900.

3.2.1.2 Bond thickness

The optical bond thickness measured at the four corners of each PDA shall be within the range 0.9 ± 0.1 mm (LAT-SS-01133). Bond material shall not extend beyond the footprint of the PDA on the crystal end face.

3.2.1.3 CDE Dimensions

The dimensions to be tested are given in Table 3-2 and are called out in the CDE Assembly Drawing (LAT-DS-1900). The “CDE Total Length” is defined as the distance between the ends of the DPD pin contacts on opposite faces of the crystal, not including the extent of the interconnect wire pairs. The “CDE Cap-to-Cap Length” is defined as the distance between the outer faces of opposite end caps. The “CDE End Cap Height” is defined to be the maximum distance between two planes in contact with the Top and Bottom surfaces of the CDE. The “CDE End Cap Width” is defined to be maximum distance between two planes in contact with the Front and Rear surfaces of the CDE. On a nominal CDE, surfaces in contact with the Top, Bottom, Front, and Rear surfaces would be in contact with the molded end caps.

The maximum values of the indicated dimensions shall be tested with calibrated equipment manufactured with tolerances of ±0.1 mm or better.

Parameter	Minimum Value (mm)	Maximum Value (mm)
CDE Total Length	NA	336.3
CDE Cap-to-Cap Length	330.8	331.6

Parameter	Minimum Value (mm)	Maximum Value (mm)
CDE Envelope Height	NA	20.4
CDE Envelope Width	NA	27.2
Bondline thickness	0.8	1.0
PDA Height Location	2.40	3.40
PDA Width Location	2.15	3.15
Wrapper Skewness	NA	0.7

Table 3-2

3.2.1.4 CDE Mass

The mass of each CDE, including CsI crystal, DPDs, optical bonds, interconnect wire pairs, optical reflective wrap, and molded end caps, shall not exceed 0.80 kg (LAT-SS-01133). The measurement precision and accuracy shall not exceed 1 gram.

3.3 OPTICAL

The optical performance of each CDE shall be quantified with the CDE Muon Telescope, the design and use of which is described in LAT-PS-02571. This device records the scintillation light produced by the passage of cosmic ray muons and measured by all four PIN photodiodes of a CDE. The optical properties of 12 CDEs can be measured with the requisite accuracy in a single data run of ~12 hrs. The CDE Muon Telescope will report the following parameters.

- The absolute light yield of all four diodes measured at the center of the CDE.
- The large-to-small diode light yield ratio, PIN B / PIN A for each PDA, measured at the center of the CDE.
- The energy resolution of both large diodes for muons at the center of the CDE.
- The light asymmetry from the large diodes for muons approximately 12 cm on either side of the center of the CDE.
- The light taper of both large diodes for muons approximately 2 cm from each end of the CDE.

3.3.1 Requirements

Optical performance requirements are given in the CAL Flight Model Crystal Detector Element Specification, LAT-SS-01133, in which these parameters are defined in some detail. Table 3-3 lists the optical requirements to be tested and the respective maximum and minimum values, as appropriate.

Parameter	Minimum Value	Maximum Value
Light yield, large PIN (e/MeV)	6500	NA
Light yield, small PIN (e/MeV)	1100	NA
Light yield ratio	5	7
Light asymmetry change	0.25	0.70
Light taper	0.45	0.75
End-to-end light yield ratio	0.87	1.15
Muon energy resolution (rms)	NA	8%

Table 3-3

3.4 THERMAL STABILITY

Eight Qualification CDEs shall be set aside for thermal stability testing.

The optical performance of this CDE (Section 3.3) will be evaluated through 50 thermal cycles at atmospheric pressure in a dry nitrogen purge. The temperature range shall be –30C to +60C, with a ramp rate not to exceed 20C per hour and a soak time of not less than 1 hour. Optical performance measurements shall be made after 0, 10, 25, and 50 cycles (test intervals may be varied by ±5 cycles for convenience). Each time optical measurements are made, the CDEs shall be visually inspected (without any disassembly) for obvious delaminations.

This sample CDE may be the same CDE selected for shear strength testing. In this case, the shear test would occur following thermal cycling. Because this delays the shear test by of order two weeks, we anticipate that the thermal stability test sample and the shear strength test sample will not be the same CDE early in the flight build.

3.4.1 Requirements

The light yield of each of the four PIN photodiodes shall not decline by more than 20% at any point in thermal cycling relative to its initial value.

There shall be no noticeable physical delamination of either optical bond.

Similar tests have been performed on EM CDEs without failures. Light yields typically decline by ~5% from their initial values.

3.5 RISE TO ALTITUDE

The FM CDEs shall be capable of withstanding the time rate of change of pressure from the launch rise to altitude. One CDE shall be subjected to a pressure drop of at least 0.98 atmospheres in 60 seconds and then return to atmospheric pressure. The optical performance of this CDE (Section 3.3) shall be measured before and after the rise-to-altitude test.

3.5.1 Requirement

A decrease in light yield of 20% or more shall be deemed a failure.

3.6 BOND STRENGTH

The twelve optical bonds for six CDEs shall shear-strength tested to failure. Both PDAs shall be sheared off the crystal using a calibrated load cell, and the PDA displacement and shear-loading data shall be recorded electronically. The shearing load shall be applied uniformly over the full 21 mm × 1.8 mm side surface of the PDA ceramic. The test shall be monitored and witnessed by QA. The shear strength test procedure is given in LAT-PS-02572.

After the shear test, the crystal and sheared PDAs shall be visually inspected and then delivered to NRL with the test report. The crystal may be returned to Swales for reuse.

3.6.1 Requirement

The shear strength of the PDA bond shall exceed 0.16 N/mm^2. For the area of the FM optical bond (20.2 mm × 12.4 mm), this corresponds to a shear force of approximately 40 N. For the purpose of this test, this 40 N value shall be defined to be 9 lbf.